Science and/or Religion: a 21st Century Debate **Open Access**
Research Article

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Downward Causation – The Way How Mind and Matter Interact?

DOI 10.1515/opth-2015-0021
Received July 12, 2015; accepted September 23, 2015

Abstract: The paper analyzes Karl Popper's and John Eccles' account of mind-matter interaction and compares their use of the concept of downward causation with other more recent accounts of it, especially those of Nancey Murphy and George Ellis. The argument includes John Polkinghorne's take on Divine action, as it provides an interesting version of downward mind/matter-interaction. It will be argued that while downward causation is a speculative concept, it nevertheless remains the best approximation to a scientific perspective on mind/matter interaction that we can obtain. As a result, Popper's and Eccles' account seems to be more interesting in these regards than usually assumed, and should not continue to be overlooked in the debate.

Keywords: Downward Causation, Mind, Matter, Interaction, Divine Action

Introduction

Karl Popper and John Eccles have proposed the idea that mind can interact with matter through downward causation. What is to be made of this idea? Nancey Murphy states that nothing has come out of Eccles' project,[1] although she advocates downward causation herself. Is the concept itself therefore safe from the problems that are associated with Eccles' account? The paper analyzes Popper's and Eccles' shares in their argument, compares their argument to more recent conceptions of downward causation, and attempts a careful consideration. Insights of the Divine action debate will help further the conclusions, as we have similar scenery here when the influence of the Divine Mind on His matter of creation is envisioned.

Popper's Point of View

Popper's main goal is to maintain the Kantian vision and therefore abandon mechanism and materialism: 'that men are ends in themselves and not "just" machines'.[2] Popper sees the danger that any other assumption would undermine humane ethics.[3] Nevertheless, he presents himself as an evolutionist - an evolutionist, however, who takes into account some sort of telos in an organic view of evolution.[4] Regarding the classic example of a giraffe's neck, he denies the Lamarckian idea of the inheritance of acquired characteristics, yet nevertheless argues that the 'actions, preferences and choices of the giraffe's ancestors ... created a

1 Murphy, *Bodies and souls*, 116.
2 Popper and Eccles, *The self and its brain*, 4.
3 Ibid., 5.
4 Ibid., 11–12.

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new environment for its descendants, with new selection pressures; and these led to the selection of long necks'.[5] Although Donald T. Campbell is not mentioned at this point, Popper's ideas point already in his direction.

Against the view that 'there is no new thing under the sun' (Eccl.1:9), Popper perceives the universe as creative and inventive and believes its evolution has produced 'real novelty'.[6] 'With the emergence of man, the creativity of the universe has, I think, become obvious. For man has created a new objective world, the world of products of the human mind...',[7] called by Popper 'world 3' – something new compared to world 2 (the world of subjective experiences), in which sentient animals have a share and also different from world 1, the world of physical (including living) objects.[8] Popper admits 'whenever we can explain entities and events on a higher level by those of a lower level, we can speak of a great scientific success';[9] nevertheless his idea of an emergent world 2 and world 3 is, of course, contradictory to a complete reductionist research program. Against the assumption 'that what happens on a higher level can be explained in terms of the next lower level, and ultimately in terms of elementary particles and the relevant physical laws',[10] Popper invokes D.T. Campbell's idea of downward causation: '...the whole, the macro structure, may, qua whole, act upon a photon or an elementary particle or an atom.'[11]

Popper's first example is a crystal which 'interacts as a whole extended periodic structure with the photons or the particles of a beam of photons or of particles'.[12] Further examples include 'all tools and machines which are designed for some purpose'.[13] In this way we arrive back at Michael Polanyi's original mechanist example in his article 'Life's irreducible Structure',[14] which inspired Campbell to coin the term.

In his article, Polanyi analyzed the structure of machines, as for centuries, 'the workings of life have been likened to the working of machines and physiology has been seeking to interpret the organism as a complex network of mechanisms'.[15] He argues that machines work under the control of two distinct principles: 'The higher one is the principle of the machine's design, and this harnesses the lower one, which consists in the physical-chemical processes on which the machine relies.'[16] Any organism is shown to be like a machine: 'a system which works according to two different principles: its structure serves as a boundary condition harnessing the physical-chemical processes by which its organs perform their functions.'[17] The structure of these machine-like boundaries can of course not be defined in terms of the laws that they harness. 'Therefore, if the structure of living things is a set of boundary conditions, this structure is extraneous to the laws of physics and chemistry which the organism is harnessing. Thus the morphology of living things transcends the laws of physics and chemistry.'[18] Polanyi argues further that the pattern of organic bases in DNA, which functions as the genetic code, is 'a boundary condition irreducible to physics and chemistry'.[19] Also, the relation of mind to body would have a similar structure. 'Further controlling principles of life may be represented as a hierarchy of boundary conditions extending, in the case of man, to consciousness and responsibility.'[20]

Campbell picks up this idea as he supports Polanyi's intent to save social values from reductionist deconstruction, although he considers himself a reductionist. He concurs that 'Life's irreducible structure'

5 Ibid., 12.
6 Ibid., 14.
7 Ibid., 15.
8 Ibid., 16.
9 Ibid., 18.
10 Ibid., 19.
11 Ibid.
12 Ibid.
13 Ibid.
14 Polanyi, "Life's Irreducible Structure," 1308.
15 Ibid.
16 Ibid.
17 Ibid.
18 Ibid., 1309.
19 Ibid., 1312.
20 Ibid.

can not be reduced to the two principles that 1) 'all processes at higher levels are restrained by and act in conformity to the laws of lower levels' and 2) that 'the teleonomic achievements at higher levels require for their implementation specific lower-level mechanisms and processes'[21] only. Instead, he proposed two additional principles: 3) the emergentist principle and 4) downward causation: 'all processes at the lower levels of a hierarchy are restrained by and act in conformity to the laws of the higher levels'.[22]

Campbell's example is termite jaws. A *worker* termite's 'hinge surfaces and the muscle attachments agree with Archimedes' laws of levers .... They are optimally designed to apply the maximum force at a useful distance from the hinge. ... We need the laws of levers, and organismlevel selection ..., to explain the particular distribution of proteins found in the jaw and hence the DNA templates guiding their production.'[23] In the jaws of *soldier* termites, even more striking cases of emergence and downward causation are encountered, as they cannot feed themselves. 'The soldier's jaws and the distribution of protein therein ... require for their explanation certain laws of sociology centring around division-of-labor social organisation.'[24]

To me, this comes close to Popper's idea of environmental selection. Nevertheless, the 'examples of downward causation ... in organisms and in their ecological systems',[25] which Popper provides himself, are quite basic (for instance the integration of a living organism). They still 'make the existence of downward causation obvious'[26] to him.

Popper admits that his idea of 'creative' or 'emergent' evolution is 'somewhat vague'.[27] The counter-arguments of determinists, atomists and the upholders of a theory of potentialities (including panpsychism),[28] however, are based on 'classical physics and its apparently deterministic character',[29] says Popper. Quantum mechanics introduced 'objective probability statements'[30] and hence we are to abandon Laplacean determinism. 'We can admit that the world does not change in so far as certain universal laws remain invariant. But there are other important and interesting lawlike aspects – especially probabilistic propensities – that do change'.[31] Therefore he enforces his ideas in favor of emergence. The world is made of indeterministic *clouds* rather than deterministic *clocks*, he is convinced. This is an important premise for the possibility of downward causation. '...the emergence of hierarchical levels or layers, and of an interaction between them, depends upon a fundamental indeterminism of the physical universe.'[32]

In dialogue with Eccles,[33] Popper admits that 'quantum theoretical indeterminacy in a sense cannot help, because this leads merely to probabilistic laws, and we do not wish to say that such things as free decisions are just probabilistic affairs.'[34] Hence, he hints toward the 'striking similarity' of ideas to genetic mutations, which are indeed brought about by quantum theoretical indeterminacy. On the range of possibilities brought about by a probabilistic and quantum mechanically characterized set of proposals operates 'a kind of selective procedure' which eliminates those proposals and possibilities not acceptable to the mind (by World 3 standards). Thus, he is suggesting 'we might conceive of the openness of World 1 to World 2 somewhat on the lines of impact of selection pressures on mutations'[35].

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21 Campbell, "'Downward Causation'," 180.

22 Ibid. This quote may explain why biochemist (and priest) Arthur Peacocke later in his writings starts to use the term "whole-part constraint" for the notion of downward causation. He explains this change in Peacocke, "God's interaction with the world", 272 ann. 22.

23 Ibid., 181

24 Ibid.

25 Popper and Eccles, *The self and its brain*, 20.

26 Ibid.

27 Ibid., 22.

28 See Popper's detailed argument against these stances: ibid., 22-24.

29 Ibid., 24.

30 Ibid., 25.

31 Ibid.

32 Ibid., 35.

33 Both have known and consulted each other rather early in their scientific career, see Eccles, "My Living Dialogue with Popper."

34 Popper and Eccles, *The self and its brain*, 540.

35 Ibid.

This poses a problem with the laws of thermodynamics, to which Popper answers: 'The action of the mind on the brain may consist in allowing certain fluctuations to lead to the firing of neurons while others would merely lead to a slight rise in the temperature of the brain. This is one of the possible ways to "sculpture" (and to save the law of the conversation of energy). ... We only have to assume that the brain gets tired under mental activity and that this tiredness in some way or other equivalent to heat production, and so to a degradation of energy, and that the second law is thus preserved.'[36]

Eccles' Contribution

In his part of the book, Eccles tries to flesh out how this is to be imagined, especially in chapter E7, which is 'devoted to the development of a new theory relating to the manner in which the self-conscious mind and the brain interact.'[37]

From the outset, Eccles takes side with a 'very strong dualism',[38] elsewhere explicitly identified by him with the Cartesian idea.[39] He develops his theory in terms of the three-world hypothesis of Popper. 'It is argued that the world of the self-conscious mind (World 2) of each individual self is developed in relationship to the World 3 influence on that self.'[40] The central claim is that the self-conscious mind is an 'independent entity',[41] which 'during normal life is engaged in searching for brain events that are in its present interest and in integrating these into the unified conscious experience that we have from moment to moment.'[42]

Where, then, is the mind to be situated in the brain, one could ask. Roger W. Sperry's investigations on commissurotomy patients[43] (who had their *corpus callosum* bisected and hence their brain split, to treat severe epilepsy) led to the claim that 'self-conscious experiences arise only in relationship to activities in the dominant hemisphere', so 'only a specialized zone of the cerebral hemispheres is in liaison with the self-conscious mind.'[44] In contrast to earlier considerations,[45] Eccles also suggests, however, that 'normally there may well be some liaison areas of brain in the minor hemisphere' as well.[46]

Eccles subscribes to the goal of the neurosciences 'to formulate a theory that can in principle provide a complete explanation of all behavior of animals and man, including man's verbal behavior.'[47] He is convinced, however, that this reductionist strategy 'will fail in the attempt to account for the higher levels of conscious performance of the human brain'. For these higher levels 'it is proposed that superimposed upon the neural machinery in all its performance, ...there are at certain sites of the cerebral hemisphere (the liaison areas) effective interactions with the self-conscious mind, both in receiving and giving.'[48]

In accordance with Popper's three-world concept, Eccles states: '...at the core of World 2, there is the self or the ego that is the basis of the personal identity and continuity that each of us experiences throughout our lifetime,'[49] embedded in the inner and outer senses.

His *hypothesis* is briefly: 'The self-conscious mind is actively engaged in reading out from the multitude of active centres at the highest level of brain activity, namely the liaison areas of the dominant cerebral

36 Ibid., 541.
37 Ibid., 355.
38 Ibid.
39 Eccles, "Cerebral Activity and Consciousness," 88.
40 Popper and Eccles, *The self and its brain*, 355.
41 Ibid.
42 Ibid., 356.
43 For references, see Eccles, "Cerebral Activity and Consciousness," 91.
44 Popper and Eccles, *The self and its brain*, 358.
45 Eccles, "Cerebral Activity and Consciousness."
46 Popper and Eccles, *The self and its brain*, 358. Cf. the figure E 7-5 p. 375 to figure E 5-8 p. 327.
47 Ibid.
48 Ibid., 359. Cf. also the detailed account in the dialogue part III of the book, as hinted in Eccles, "My Living Dialogue with Popper," 233–36.
49 Popper and Eccles, *The self and its brain*, 360.

hemisphere. The self-conscious mind selects from these centres according to attention, and from moment to moment integrates its selection to give unity even to the most transient experiences. Furthermore, the self-conscious mind acts upon these neural centres modifying the dynamic spatiotemporal patterns of neural events.'[50]

How exactly does the mind act on these neural centres? To understand Eccles theory in these regards, 'we must consider the organization of the cortical neurons in the anatomical and physiological entity that is called a module,'[51] 'ensembles of neurons (many hundreds) acting in some collusive patterned array.'[52] We may conjecture, says Eccles, that such a module 'with its complexly organized and intensely active properties, ... could be a component of the physical world (World 1) that is open to the self-conscious mind (World 2) both for receiving from and for giving to', although 'not all modules in the cerebral cortex have this transcendent property of being "open" to World 2.'[53] However, by its interaction with "open" modules, the self-conscious mind can indirectly interact with "closed" modules'[54] as well.

As one could conclude, from such a close interaction of a philosopher of science and a neuroscientist, that the theory they develop would be in agreement with the fundamental principles of the theory of science. While the idea of the psychoneural identity hypothesis, that is parallelism, has – according to Eccles – been falsified by the split-brain investigations (which have shown that in these cases the minor hemisphere does not give any conscious experiences to the subject[55]), it can be claimed that Eccles 'hypothesis belongs to science because it is based on empirical data and is objectively testable.'[56]

Eccles acknowledges, however, that the question 'where is the self-conscious mind located?' remains unanswerable in principle.[57]

Recent Concepts and Critiques of Downward Causation

That is perhaps why 'nothing has come out of this project.'[58] Nancey Murphy convincingly argues that dualism is a rather outdated concept in her book Bodies and Souls, or Spirited Bodies? This may have to do with her own explicitly physicalist convictions as well. When it comes to downward causation, she is nevertheless convinced that this concept 'has been used extensively in the sciences.'[59] To this conviction, she already subscribed to earlier,[60] although she only manages to provide two scientific examples, which are Roger Sperry and Donald Campbell.[61] As we have seen, Popper and Eccles used the two researchers intensively in their account.

In the volume edited by Murphy, Christof Koch criticizes Popper and Eccles, knowing 'these are both reputable scholars.'[62] Popper's use of Campbell's concept of downward causation is not mentioned at all. While also the reference to Popper's world 2 remains vague, the focus is on Eccles idea that 'the conscious mind ... imposes its will onto the brain by affecting the way neurons communicate with each other in the part of the cerebral cortex concerned with the planning of movement and action.'[63]. Koch's classification of

50 Ibid., 362.
51 Ibid., 366, see Eccles E1.3-4.
52 Ibid.
53 Ibid.
54 Ibid., 370.
55 Eccles, "Cerebral Activity and Consciousness," 102.
56 Popper and Eccles, *The self and its brain*, 375.
57 Ibid., 376.
58 Murphy, *Bodies and souls, or spirited bodies?*, 116.
59 Murphy, "Introduction and Overview," 5.
60 Murphy, "Theology, Cosmology, and Ethics."
61 Murphy, "Introduction and Overview," 5. Unfortunately Murphy does not indicate in her article, to which articles of Sperry she relates to.
62 Koch, "Free Will, Physics, Biology and the Brain," 41.
63 Ibid.

this mind as 'made out of some sort of metaphysical ectoplasm'[64] points to the metaphysical difficulties he detects in the idea. '...if the mind interacts in the material world, it has to do work and this costs energy'[65], while something like a ghost or a spirit 'cannot interact with our universe'[66], or else it would have to be some 'poltergeist, rumbling and tugging synapses'[67]. The only freedom such a mind could have, therefore, 'is to realize one quantum-mechanical event rather than another one as dictated by Schrödinger's law'[68]. This sort of action would always remain covert for sure. Koch admits that such ideas 'cannot be ruled out' at least[69].

Koch himself is critical of the idea of free will in general. He refers to the famous experiments by Benjamin Libet[70], according to which 'the beginning of the readiness potential preceded the conscious decision to move by 0.3 and 0.5 sec. That is, the brain acted before the conscious mind did!'[71], which would refute mental causation. Nevertheless, unnoticed by Koch, Eccles interprets Libet's experiments quite differently; for him his 'hypothesis helps to resolve and redefine problems involved in accounting for the long duration of the readiness potential that precedes a voluntary action'[72]. This duration 'is a sign that the action of the self-conscious mind on the brain is not of demanding strength. We may regard it as being more tentative and subtle and as requiring time to build up patterns of activity that may be modified as they develop.'[73] Murphy points to the fact that Libet 'has done further research showing that subjects can veto the action after feeling the urge to act. He locates free will in this veto power'[74], which again would fit nicely with the idea how Popper and Eccles view the selection process of the mind out of a burst of ideas. It is interesting that Koch does not take notice of these further results. This demonstrates to me quite clearly the impact that our belief systems and metaphysical convictions have on our selective perception, even of science. Koch's creed is that the 'universe is causally closed. All the mind could accomplish is to realize one of several quantum mechanical possibilities, without being able to do anything about the underlying probabilities.'[75] This indeed would be a 'meager freedom' only.

It may have been George Ellis who left Nancey Murphy with the impression that downward causation is an undisputed matter of scientific fact. The two had previously collaborated on a book[76], and in his contribution to Murphy's volume on downward causation, Ellis assumes that different sorts of downward causation are 'ubiquitous in physics, chemistry, and biology, because the outcome of lower-level interactions is always determined by context.'[77] The problem that always remains is well formulated by Ellis: 'For higher levels to be causally efficacious over lower levels, there has to be some causal slack at the lower levels, otherwise the lower levels would be causally overdetermined.'[78] So the universe has to be indeterministic at a profound level, allowing the needed causal slack[79]. This is a strong claim, related to physicists like Feynman and Polkinghorne, which in the case of the latter we will examine further, as Polkinghorne is also contributing to the debate of downward causation in a most interesting manner.

Before doing this, however, Nancey Murphy's account of downward causation should be briefly considered. Like Ellis, she portrays the main difficulty with the concept as persisting in the problem of overdetermination: 'Where is there room for additional downward causal influences if the behavior of the

64 Ibid.
65 Ibid.
66 Ibid.
67 Ibid.
68 Ibid.
69 Ibid., 42
70 Libet *et al.*, "Time of conscious intention."
71 Koch, "Free Will, Physics, Biology and the Brain," 46.
72 Popper and Eccles, *The self and its brain*, 365.
73 Ibid.
74 Murphy, "Introduction and Overview," 8; with reference to Libet, "Do we have free will?."
75 Koch, "Free Will, Physics, Biology and the Brain," 49.
76 Murphy and Ellis, *On the moral nature of the universe*.
77 Ellis,"Top-Down Causation and the Human Brain," 66.
78 Ibid., 74.
79 Ibid., 75.

lower-level entities is already determined by the laws of that level?[80]' For her, the answer is provided by Donald Campbell's idea 'that downward causation is not overpowering but selective activation of lower-level processes.'[81]

As 'one of the best examples' for this idea, Murphy marks the effect of the environment on the developing brain[82]. '...useful connections are strengthened, while unused connections weaken or die off.'[83] The basic idea to me does not seem to be so far away from Popper's account, although in his theory it is, of course, the self-conscious mind that selects the ideas to be pursued and not simply the environmental pressures. Nevertheless, I guess Popper would have been open for Murphy's interpretation, and it would have been most wise to take Popper's and Eccles' point of view into account.

Polkinghorne's Account of Downward Causation

In my view, the metaphysical ideas of Cambridge particle physicist and later priest John Polkinghorne provide an interesting answer to many of the issues raised in our review of downward causation. So far, we have identified the most pressing problem to be a necessary physicalism while having to assume the causal closeness of the physical world. Polkinghorne's account, although speculative as well, is striking because it acknowledges all the physical difficulties involved in downward causation *and* offers a potential metaphysical solution, risky as it may be.

His metaphysical stance is dual-aspect monism: 'a complementary world of mind/matter in which these polar opposites cohere as contrasting aspects of the world-stuff'[84]. 'Neither soul nor entelechy will be found as a separate part of the residue. Yet if you want to encounter *me* you will have to refrain from that act of decomposition and accept me in my complex and delicately organized totality.'[85] In a quite Aristotelian manner, Polkinghorne goes on: 'That almost infinitely complex information-carrying pattern, which persists through all the changes of material constituents as nutrition and wear-and-tear ceaselessly replace the individual atoms of my body, and which by its very persistence express the true continuity of my person, that pattern is the meaning of the soul.'[86]

Although Polkinghorne wants to defend our freedom to act[87], he is critical of attempts to equate quantum indeterminacy with human freedom. Instead, he offers an open interpretation of chaotic systems in classical physics, his take on Popper's *clouds* so to speak. Polkinghorne interprets the unpredictability of chaotic systems as intrinsic openness for downward causational influences. He is aware of the deterministic equations underlying even these chaotic systems, yet interprets this determinism as an approximation to a more differentiated and more flexible description of reality[88]. Hence, he views determinism as a *downward emergent property* resulting from the isolated examination of systems.

Polkinghorne also considers how exactly downward causation could take place. He needs this concept especially in order to preserve the possibility of God's (the pure mind, according to Polkinghorne) action in the physical world, yet I suppose one can apply his ideas to the human mind's action on its body as well, taking for granted that we are 'psychosomatic unities, indivisible animated bodies'[89]. 'There is no totally separate realm of spiritual encounter, divorced from the physical/mental reality of a dual-aspect monistic world, in which providence can act.'[90] Hence for Polkinghorne, our problem is first of all of a *theological* character.

80 Murphy, *Bodies and souls, or spirited bodies?*, 78.
81 Ibid., 83.
82 Ibid.
83 Ibid., 84.
84 Polkinghorne, *Science and creation*, 71.
85 Ibid., 72.
86 Ibid.
87 Polkinghorne, *Science and providence*, 2.
88 Polkinghorne, "Ordnung und Chaos," 369.
89 Polkinghorne, *Belief in God in an age of science*, 49.
90 Ibid., 55.

He adopts the idea of downward causation from Arthur Peacocke to answer this problem[91], although he is aware of its difficulties. What Ellis called the 'causal slack' also appears problematic to Polkinghorne: 'One has to ask the question of how it may be supposed that there is room for the operation of this additional holistic causal principle within the network of physical causality established by the interactions of the bits and pieces making up the whole. ... In some sense there must be gaps in the bottom-up account which this top-down action fills in, but those gaps must be intrinsic and ontological in character and not just ignorances of the details of the bottom-up process.'[92] One should note that also Nancey Murphy seems to have encountered the idea of downward causation in the context of concepts of Divine Action at first[93]. In contrast to Murphy, however[94], particle physicist Polkinghorne refuses to follow the trend to explore the uncertainties of quantum events in these regards, and that is because of the so-called *measurement problem*. I do not want to explain this concept here, but want to point to Polkinghorne's conclusion: '...if quantum theory does have a role to play in solving the problem of agency, it will only be because its effects are amplified in some way to produce an openness at the level of classical physics.'[95] And that is why he turns to chaotic systems, more specifically to 'the way a chaotic system traverses its strange attractor'[96], taking the metaphysical freedom to interpret their deterministic mathematical basis as a downward emergent property. The divergent trajectories 'all correspond to the same total energy'[97] and hence a modulation of these trajectories through downward 'active information' may be portrayed as having an impact without violating the causal nexus of the physical world[98]. 'Here we see a *glimmer* of how it might be that we execute our willed intentions and how God exercises providential interaction with creation. As embodied being, humans may be expected both energetically and informationally. As pure spirit, God might be expected to act solely through information input.'[99] This sort of *active information* appears as an appealing concept to me, though I do not understand how it should help humans as 'mind-matter amphibians'. If we are supposed to act energetically as well, all the problems with the causal nexus of physics for intentional actions remain. Also, as already said, the assumption that the deterministic character of chaotic systems is a *downward emergent property* is, of course, a metaphysically very speculative move[100].

Conclusion: A 'Spooky Force'?

Even Christof Koch acknowledges that 'our knowledge is only a fire lighting up the vast darkness around us, flickering in the wind.'[101] If one would like to call the idea of downward causation a 'spooky force', one should not forget that another such spooky force in the meantime has proved to be real by physics. It was even Einstein who had erred here.

Nevertheless, there are indeed very many highly speculative aspects of the idea of downward causation, not to tackle the premise of emergence as a necessary underlying concept at all[102].

What are the alternatives? Popper noted already at the end of the seventies that a "radical materialism" had become fashionable amongst philosophy students[103]. Given the utterings

91 Ibid., 58 ann. 13. It would be a worthwile enterprise to sketch how Polkinghorne especially distinguishes himself from Peacocke. Cf. also ann. 33 above.
92 Ibid., 58.59.
93 See Russell, *Neuroscience and the person*.
94 See Polkinghorne, *Belief in God in an age of science*, 59 ann.15.
95 Ibid., 60.
96 Ibid., 61.
97 Ibid.
98 This may be by influence on their quantum level initial conditions, although Polkinghorne is careful to draw this conclusion, see ibid., 63–64.
99 Ibid., 62–63.
100 For a critique, see Russell, *Cosmology*, 129–32.
101 Koch, "Free Will, Physics, Biology and the Brain," 50.
102 For a discussion of these issues see Andersen *et al.*, *Downward causation*.
103 Popper and Eccles, *The self and its brain*, 52.

of modern neurobiologists and philosophers of neuroscience, the situation in this discipline regarding divergent philosophical stances (like the dualism Popper and Eccles propose[104]) is as difficult today as Popper foretold. The reality of mind remains the big question of our time. We can, of course, regard the self as an illusion[105], and surrender to the spirit of the scientific age. Or we may keep up an epistemological dualism and separate science from humanities, and being from ought. Maybe the very method of science also does not allow for a scientific treatment of the mind. What I finally find fascinating with the account of downward causation is that it tries to elaborate on basic insights of human experience in a scientific manner. Promising or challenging as this may prove, there is still some work to do regarding the underlying metaphysical concepts. If Cartesian dualism will not do, maybe a dual-aspect monism has better chances – if it were clearer what this actually means and whether the 'top' and the 'bottom' then are sufficiently separate for one to have a causal influence on the other.

References

Andersen, Peter B., Claus Emmeche, Niels O. Finnemann, and Peder V. Christiansen. *Downward causation: Minds, bodies and matter*. Aarhus: Aarhus Univ. Press, 2000.

Ayala, Francisco J. and Theodosius Dobzhansky, eds. *Studies in the philosophy of biology: Reduction and related problems*. London: Macmillan, 1974.

Campbell, Donald T. "'Downward Causation' in Hierarchically Organised Biological Systems." In Ayala; Dobzhansky, *Studies in the philosophy of biology*, 179–86.

Eccles, John C. "Cerebral Activity and Consciousness." In Ayala; Dobzhansky, *Studies in the philosophy of biology*, 87–108.

Eccles, John C. "My Living Dialogue with Popper." In *In pursuit of truth: Essays on the philosophy of Karl Popper on the occasion of his 80th birthday*. Edited by Paul Levinson, 221–36. Atlantic Highlands, N.J., Sussex, England: Humanities Press; Harvester Press, 1982.

Ellis, George F. R. "Top-Down Causation and the Human Brain." In Murphy; Ellis, George F. R; O'Connor, *Downward causation and the neurobiology of free will*, 63–82.

Koch, Christof. "Free Will, Physics, Biology and the Brain." In Murphy; Ellis, George F. R; O'Connor, *Downward causation and the neurobiology of free will*, 31–52.

Libet, Benjamin. "Do we have free will?" *Journal of Consciousness Studies* 6, 8-9 (1999): 47–57.

Libet, Benjamin, Curtis A. Gleasonm, Elwood W. Wright and Dennis K. Pearl. "Time of conscious intention to act in relation to onset of cerebral activity (Readiness-Potential)." *Brain* 106, no. 3 (1983): 623–42. doi:10.1093/brain/106.3.623.

Metzinger, Thomas. *Being no one: The self-model theory of subjectivity*. Cambridge, Mass.: MIT Press, 2003.

Murphy, Nancey C. "Theology, Cosmology, and Ethics." In *Science and theology: The new consonance*. Edited by Ted Peters, 103–17. Boulder, Colo.: Westview Press, 1998.

Murphy, Nancey C. *Bodies and souls, or spirited bodies?* Current issues in theology. Cambridge, UK, New York: Cambridge University Press, 2006.

Murphy, Nancey C. "Introduction and Overview." In Murphy; Ellis, George F. R; O'Connor, *Downward causation and the neurobiology of free will*, 1–30.

Murphy, Nancey C., and Ellis, George F. R. *On the moral nature of the universe: Theology, cosmology, and ethics*. Theology and the sciences. Minneapolis, Minn.: Fortress Press, 1996.

Murphy, Nancey C., Ellis, George F. R, and Timothy O'Connor, eds. *Downward causation and the neurobiology of free will*. Understanding complex systems. Berlin: Springer, 2009.

Peacocke, A. "God's interaction with the world" In *Chaos and Complexity*. Scientific Perspectives on Divine Action. Edited by Robert John Russell, Nancey Murphy and Arthur Peacocke, 263-287. Vatican Observatory Foundation, 1995.

Polanyi, M. "Life's Irreducible Structure: Live mechanisms and information in DNA are boundary conditions with a sequence of boundaries above them." *Science* 160, no. 3834 (1968): 1308–12. doi:10.1126/science.160.3834.1308.

Polkinghorne, J. C. *Science and creation: The search for understanding*. London: SPCK, 1988.

Polkinghorne, J. C. *Science and providence*. SPCK, 1989.

Polkinghorne, J. C. *Belief in God in an age of science*. The Terry lectures. New Haven, CT: Yale University Press, 1998.

Polkinghorne, J. C. "Ordnung und Chaos." In *Theologische Realenzyklopädie*. Edited by Gerhard Krause and Gerhard Müller. Studienausg, 367–71. De-Gruyter-Studienbuch. Berlin, New York: de Gruyter, 2000.

Popper, Karl R., and John C. Eccles. *The self and its brain*. New York: Springer International, 1977.

104 Ibid., ix.

105 Metzinger, *Being no one*.

Russell, Robert J. *Neuroscience and the person: Scientific perspectives on divine action.* Series on "Scientific perspectives on divine action" 4th v. Vatican City State, Berkeley, Calif.: Vatican Observatory; Center for Theology and the Natural Sciences, 1999.

Russell, Robert J. *Cosmology: From alpha to omega the creative mutual interaction of theology and science.* Theology and the sciences. Minneapolis: Fortress Press, 2008.